

# The Development of a New Paper Pallet Machine

Chi-Wei Chen\*

Department of Marketing and Distribution Management, Tajen University, Pingtung, Taiwan, ROC.

Received 13 July 2017; received in revised form 15 July 2017, accepted 19 July 2017

## Abstract

In modern industry world, logistics plays an import role of enhancing the efficiency of shipping goods by use of pallets. The shipping pallets used in modern industry sites are generally made of metal, plastic, wood, or paper. Among them, the wood pallet is used most often by many firms because of low manufacturing cost. However, a wood pallet is not the best shipping selection by use in the area of air cargo transportation because of its weight and from the perspective of environmental preservation. Thus, for air cargo transportation, paper pallet is a better shipping selection because of its light weight advantage and also a good shipping tool for upgrading the competitiveness of Taiwan's electronic industry by reducing its air cargo shipping cost. In current paper pallet manufacturing machine requires many workers to work with and also generates many wasted papers, which is not a good way from the perspective of reducing cost and environmental preservation. A new manufacturing approach was thus proposed and a new machine was also designed to manufacture the newly designed paper pallet. The new paper pallet design was successfully implemented and the new prototype machine was also successfully developed. At least 20% of paper was saved comparing to the same size of paper pallet made by the current best existing paper pallet machine. And the workers used in new manufacturing process of making paper pallet were also reduced at least 10 workers comparing to the process of current existing paper pallet manufacturing machine.

**Keywords:** paper pallet design, paper pallet machine, air cargo transportation, supply chain management, logistics management

## 1. Introduction

During the product manufacturing process and shipping process of finished goods, logistics area was not being paid enough attention by many industries. Thus, in 1962, Peter Drucker called the area of logistics is "The economy's dark continent" [1-2]. The major reason is that many manufacturing firms are always seeking or making new machines, or develop new manufacturing processes to increase their productivities. In recent 20 years, there are more manufacturing firms realize to increase the efficiency of supply chain operation is also an import mean to enhance overall productivities. Thus, this paper is intended to propose a new paper pallet design and a new paper pallet machine to enhance the efficiency of logistics operation.

Traditional marine shipping cargo is in the size of 20 or 40-foot long(X8-foot width X 8-foot height) container and usually use pallets with standard specification of 80X120cm or 100X120cm(Euro spec.), 110X110cm(JIS Spec.), 110X110cm or 100X120cm(CNS-Taiwan Spec.) . In 2007, Singapore, Shanghai, Hong Kong ,Shenzhen, Yingkou(Liaonian, China), Kaoshiung are in the Top 10 list of marine cargo import and export amount (20-foot equivalent unit, TUE) , which was shown in Table 1 and the international airport air cargo shipping amount was shown in Table 2[3].

\*Corresponding author. E-mail address: [cthomas@tjen.edu.tw](mailto:cthomas@tjen.edu.tw)

Tel: +886-8-7624002 ext.3213

Table 1 2007 World Harbor Ranking by import/export cargo

Cargo import/export amount (TUEs)			
Ranking	Harbor name	Country	TUEs
1	Singapore	Singapore	27,935,500
2	Shanghai	China	26,152,400
3	Hong Kong	China	23,998,440
4	Shenzhen	China	21,103,800
5	Yingkou	(Liaonian, China)	13,713,000
6	Busan	South Korea	13,254,703
7	Rotterdam	Netherlands	10,790,604
8	Dubai	UAE	10,653,026
9	Kaoshiung	Taiwan	10,256,829
10	Hamburg	Germany	9,917,180

In the case of marine shipping cargo, each TUE needs at least about 10 standard pallets to support unit loads of products. Therefore, huge amount of pallets are needed in this globalization modern world. Also huge amount of pallets are made of wood and some special goods requested plastic pallets. And some heavy products need metal pallets to carry goods. Wood pallets are most often used by manufacturing firms because of its low cost. However, if goods are manufactured in Taiwan or China and are needed to be shipped to Developed Countries, such as USA, UK, or most European countries, wood pallets are needed to add up smoking treatment and discard cost(usually burning cost), which is not a cost effect method to handle over a shipping. The most difficult task for Taiwan or China manufacturing firms to reduce the shipping cost is that an efficient machine is not existed in modern world wide. Paper pallets are always only one-third of weight amount of the same size wood pallets. In the area of air cargo shipping, paper pallets have large advantages of reducing shipping cost. And about 75% of wood pallets could be replaced by paper pallets.

Regarding air cargo transportation, as in Table 2, Taiwan and China occupied Top list of international air cargo ranking and indeed both Taiwan and China have many electronic products are needed to be shipped to countries worldwide. Thus paper pallets are in big help of reducing shipping cost by using its light weight advantage and also in the perspective of environmental preservations.

Table 2 2008 International Airport Ranking by import/export cargo

Cargo import/export amount (Tons)			
Ranking	International Airport	Country	Tons
1	Memphis International Airport	USA	3,695,438
2	Hong Kong International Airport	China	3,660,901
3	Shanghai Pudong International Airport	China	2,602,916
4	Incheon International Airport	South Korea	2,423,717
10	Singapore Changi Airport	Singapore	1,883,894
15	Taiwan Taoyuan International Airport	Taiwan	1,493,120

The proposed newly designed paper pallet machine is going to generate a new environmental protection business with a manufacturing process without waste water and waste air produced. Its manufacturing material could be from recycled papers and its scraps could be recycled and shipped to paper manufacturing factories to be used as raw materials.

## 2. Existing Paper Pallet Machine and Paper Pallet Designs

As mentioned above, both Taiwan and China have large amount of electronic products need to be shipped by air cargo to many foreign countries worldwide. Thus, the demand of paper pallets is numerous. Comparing to the end price between wood and paper pallets, wood pallets will not have much more advantages than paper pallets. However, in the case of air cargo shipping, paper pallets will be a better selection than wood pallets. In 2009, European Union was intended to force other countries sellers to use paper pallets to ship goods to enter European Union countries. This decision was hold back, because there is no efficient paper pallet machine available in recent industry markets.

In Taiwan, there are about 30 small companies in the business as paper pallets suppliers. The manufacturing method used is all in a very old fashion way, purely made by human hands and simple tools, and without any mechanical designs and calculations. The situation in China is that some manufacturing firms are using a paper pallet machine designed by Netherland, which required many (at lease 20) workers to finish a complete paper pallet. The paper pallet machine developed by Netherland was not designed in a highly automation way because during its manufacturing process that it still needs many human workers to perform tasks for work-in-process. The manufacturing processes, including stage 1 and stage 2 shown in Fig. 1 and Fig. 2 respectively, are as follows:

Stage 1. Manufacturing the core material of a bee-hives type paper pallet:

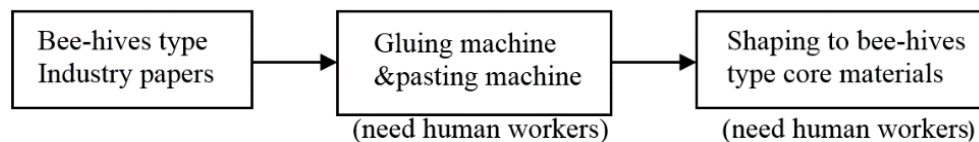


Fig. 1 The flow chart of making core materials of a bee-hives type paper pallet

Stage 2. Forming a paper pallet

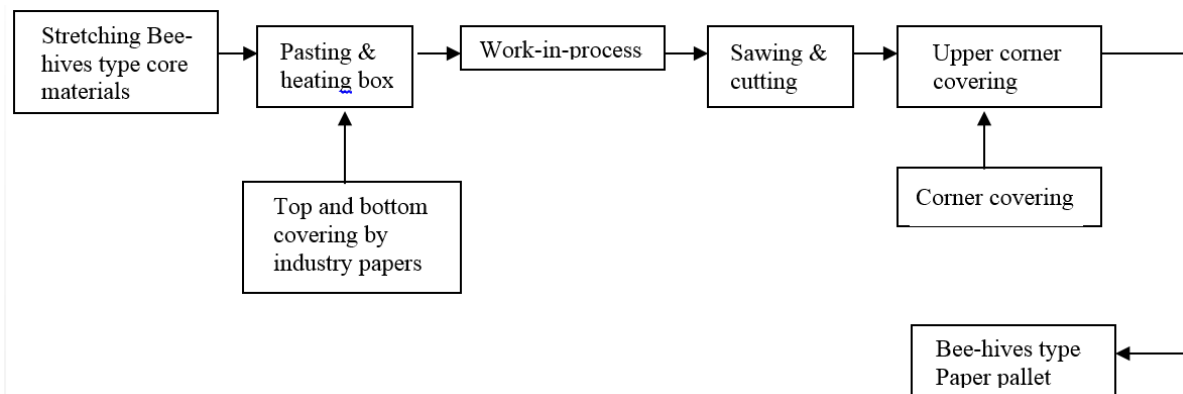


Fig. 2 The flow chart of making a complete bee-hives type paper pallet

This type of paper pallet is strong enough to support a unit load of electronic products whose average weight is usually less than 500kgs. Usually for the bee-hives type paper pallets, static carrying strength could go up to more than 1000kgs, while dynamic carrying weight usually less than 1000kgs because of the strength limits of the be-hives type core material. From cost management point of view, the bee-hives type paper pallet consumes too much human powers.

### 3. A Proposed New Paper Pallet Design and a New Designed Paper Pallet Machine

#### 3.1. A new paper pallet design

The proposed paper pallet design has about 20 years of innovation patent protection. The main design of paper pallet main board differs from that of bee-hives type paper pallet main board is the core material inside the main board. The core material of the proposed paper pallet has *wave type structure* and during the manufacturing process, the core material does not need human powers to perform any cutting procedure and thus will not generate any scraps.

The core material of existing bee-hives type paper pallets need human powers (at least 2 persons) to perform stretching and cutting procedure before putting core material inside industry papers for succeeding wrapping procedure. The major drawback of the previous process is the time needed for bee-hives type core material after pasting glue, heating and drying glues used for adhere outside industry papers and core material. The density of glue and the temperature of heating box are key factors affecting the manufacturing efficiency.

The proposed *wave type structure* also faced the challenge of density of glue used and the heating temperature adjustment, which were overcome eventually. The major challenges of *wave type structure* core material could be separated into two parts. First part is during shaping the *wave type structure* procedure. It will need very strong forces to transform a flat carton paper to *wave type structure*, while the wave height is the key factor of affecting final strength of paper pallets. Second part is to place a *wave type structure* core material inside a pre-molding carton flat paper and to perform a wrapping procedure. As mentioned above, in this stage, the glue density and heating temperature setting are very important factors to affect the strength of final paper pallets. This paper mainly concentrates efforts on the main board design. The manufacturing of legs used for the proposed paper pallet main board is a minor problem comparing to the consideration for designing the paper pallet machine. The legs could be manufactured by special designed small molds.

The samples of the proposed new paper pallet design are shown in Fig 3 as follows:

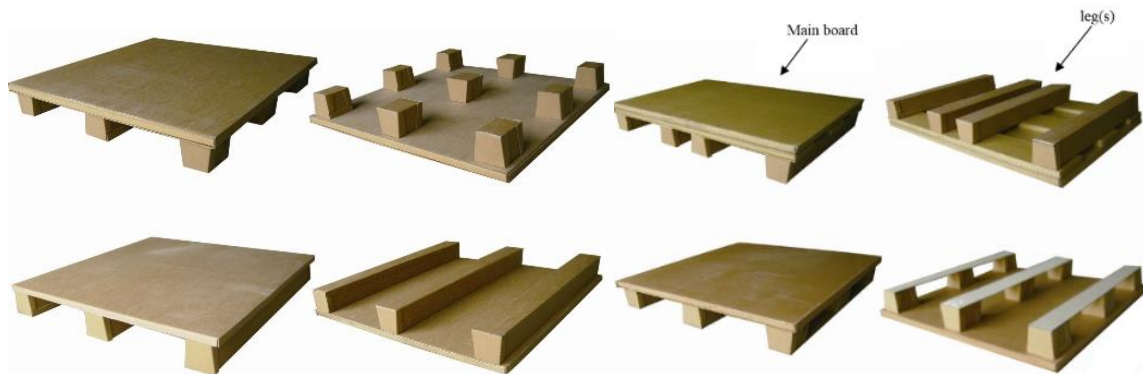


Fig. 3 The samples of proposed paper pallets

### 3.2. The proposed new paper pallet machine

In order to produce the paper pallets mentioned above, new manufacturing procedures are developed and are shown in Fig. 4 as follows. A prototype machine was also developed to perform the following procedures:

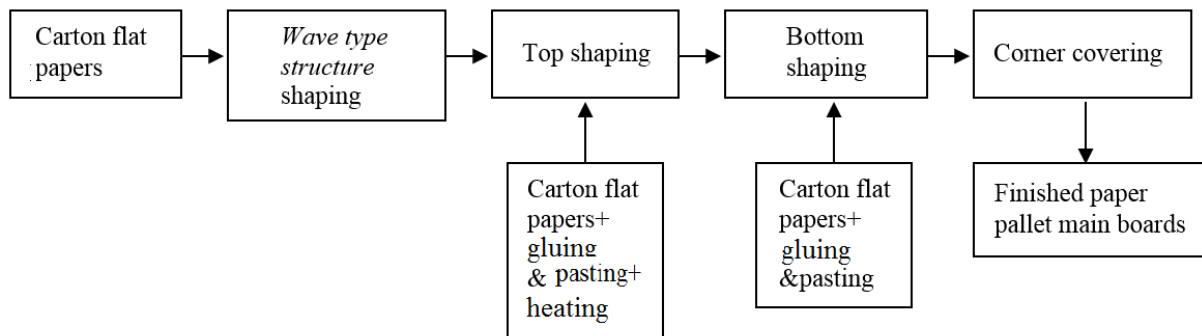


Fig. 4 The proposed new paper pallet machine working procedures

As shown in Fig. 4, whole manufacturing procedures without any cutting process, therefore, it will not generate any scraps. The major variable cost for the main boards of paper pallet is from the weight of carton papers and industry papers used, and also from the working hours of human powers used. Just simply comparing the manufacturing procedures between bee-hives type paper pallet and the proposed paper pallet, the latter shows a more efficient manufacturing procedure.

#### 3.2.1. Wave type structure shaping

In this step, a design engineer needs to calculate the strength of carton flat paper to be used [4] and the feeding speed of main machine to perform *wave type structure* shaping [5-8]. If the selection of paper strength is not correct, it will increase the risk of tearing apart the carton flat papers during the shaping *wave type structure* process, which is an important procedure that

any engineer needs to be very cautious to avoid making mistakes. If a carton flat paper was tearing apart in the paper pallet machine, the whole machine has to be shut down and the process of removing the scraps inside the paper pallet machine is needed. The situations mentioned above must be tested during test runs. As the green light starts for making the main boards of proposed paper pallet, the machine must be sure that it will perform smoothly. The feeding speed of making each main board could be adjusted up to 60 main boards per minute, however, the coming challenge is the pasting and heating speed must be adjusted to match up the feeding speed of main machine.

### 3.2.2. Gluing, pasting and heating procedures

The key factors of adhering carton flat paper with *wave type structure* are not the amount of glue used, nor the brand name of glue used, but the density of glue used and the time needed to mix the surface fibers tangled together for both carton flat papers and *wave type structure* core materials. When an engineer find the right density of glue and the time needed to put both carton flat papers and *wave type structure* together, he has solved one of the most fetal problems of making paper pallets.

For the proposed paper pallet machine, before starting the machine, a stack of carton flat papers will put in front of machine in order to feed into the machine and performing *wave type structure* shaping procedure. In the same time, the bottom position of the paper pallet machine which is designed and placed under surface ground 2 meters depth with major functions of feeding in carton flat papers, gluing, pasting on the bottom of the *wave type structure*. As soon as accomplishing the procedures mentioned above, the following step will be performing heating procedure to adhere both parts.

The following step is wrapping another pre-molding carton flat paper on the work-in-process item which is a *wave type structure* was attached on a carton flat paper. The purpose of this step is to avoid the work-in-process item decreasing its peak heights. As its peak height decreased, the strength of the paper pallet decreased. The holding force could be applied by extending the machine structure of a strip of conveyors and applying jig and fixtures to withhold the work-in-process on the conveyors while continue its glue drying process, and which can be added up to 10, maybe 100 meters or more, if needed, depending on the space of factories one has or what budget one has.

### 3.3. Purchasing cost, weight, and other factors among wood pallets, existing paper pallets in Taiwan, and the proposed paper pallet

Table 3 Comparisons of wood pallets and paper pallets (according to a pallet with 100cmX100cm, dynamic carrying weight 800kgs)

	Proposed paper pallets	Wood pallets	Existing paper pallets (in Taiwan)
Weight/each	7kgs	18~40kgs	8~12kgs
Manufacturing process	Shaping, pasting	Cutting, sawing, nailing	Gluing, pasting, cutting
Market price(NT\$)	250	280~300	260~450
Waste treatment	Recycled	Burning or burying	Recycled
Contaminant	None	Wood scraps	Paper scraps
Automation	Feasible	Half automation	Hand made

As shown in Table 3, market price and light weight advantages of proposed paper pallets are better than that of wood pallets. Compare to the producing speed between existing paper pallets manufacturers in Taiwan and the proposed paper pallet machine, the latter shows much better automation advantage. The proposed paper pallet machine also could be applied in China, since many Taiwan's electronic manufacturers have invested in China and their products are needed to be shipped to countries worldwide.

### 3.4. Other advantages of using paper pallets

Final step of discarding wood pallets is *burning* which will generate 100kgs of carbon dioxide per 100cmx100cm wood pallet. It was indicated in 2006[9] that one ton of carbon right trading price in European Union market is 20~25Euro. Thus, in the case of Shanghai port (China), the marine shipping amount is 26,152,400 TUEs (in 2007). If 75% of marine shipping amount could be transferred to paper pellets shipping, the shipping amount will be 19,614,300 TUEs. Each TUE needs about 10 pallets to accomplish unit load tasks, therefore, yearly Shanghai port will consume 196,143,000 paper pallets. Each paper pallet will reduce 100kgs of carbon dioxide generation which yearly could reduce  $196,143,000 \times 100 \text{ kgs} = 19,614,300 \text{ tons}$  of carbon dioxide. The previous amount could be transferred to money which is  $19,614,300 \times 20 \text{ Euro} = 392,286,000 \text{ Euro}$  per year.

Another fact is using recycled papers to make pallets could reduce cutting trees. Thus, using the previous data from Shanghai port, yearly it could use 196,143,000 paper pallets. Each paper pallet weights 7.5 kgs, yearly Shanghai could generate  $196,143,000 \times 7.5 \text{ kg} / 1000 \text{ kg} = 1,471,070 \text{ tons}$  of recycled papers. One ton of recycled paper will save cutting 17 trees, which means that Shanghai port yearly could save  $1,471,070 \times 17 \text{ trees} = 25,008,190 \text{ trees}$ .

## 4. Conclusions and Future Studies

In this paper, a new design of paper pallet was proposed and a new paper pallet machine was also introduced. The new proposed machine could resolve the issues related to the paper pallet machine used in China that was designed by Netherland. The labor cost is increasing dramatically lately in China, especially in Southern-East Coast area. Low labor wage is no longer a huge advantage of investing manufacturing firms in China. Electronic manufacturing firms in Taiwan or China need to pay more attention to enhance the efficiency of Global Logistic Management issues.

Also, the advantages of using paper pallets to acquire extra economic returns by engaging carbon right trading market and save cutting trees to protect our environment were also introduced. Economic development also could maintain the sustainable environment preservations.

The issue regarding shearing force of making *wave type structure* for the proposed paper pallet needs to be re-examined carefully. Experiments could also be adopted for testing the strength ranges of carton flat papers used without tearing apart during the shaping procedure. An alternative is to develop a different method of feeding carton papers, not only increasing feeding speed but also reducing the risks of occurring carton paper jams.

## References

- [1] J. D. Wisner, G. K. Leong, and K. Tan, Principles of supply chain management-a balanced approach, South Western, a division of Thomson Learning, Inc., 2005.
- [2] Peter F. Drucker, "The economy's dark continent," Fortune, p.14, April 1962.
- [3] Douglas C. Long and E. S. Su, Global Logistics Management, 2nd ed. Taipei:Hwatai Publishing Co., pp.248-249, June 2010.(In Chinese)
- [4] A. C. Ugural, Mechanics of materials, Taipei;New York:McGraw-Hill, 1991.
- [5] M. F. Spotts, T. E. Shoup, Design of Machine Elements, 7th ed., New Jersey: Simom & Schuster, 2002.
- [6] J. L. Moum, Z. Lin, S. S. Shei, etc., Applied Force-Kinematics, Taipei:Gou-Li Publisher, January 1995.(In Chinese)
- [7] Mikell P. Groover, Automation, Production System, and Computer Integrated Manufacturing, New Jersey:Prentice-Hall, Inc., 1987.
- [8] Mikell P. Groover, Fundamentals of modern manufacturing-materials, Processes, and Systems, 2nd ed., New Jersey: Prentice-Hall, Inc., 2002.
- [9] Liberty Times, Taipei, 10 June, 2006.(In Chinese)